BOTANICAL GAZETTE

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Contributions from the Cryptogamic Laboratory of Harvard University. XXVII.

New or peculiar aquatic fungi. 1. Monoblepharis.

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WITH PLATE XXIX.

The following notes are derived from observations made by the writer during the past season on certain aquatic fungi which have come under his notice, and, although other occupations have made it impossible to study some of the forms enumerated as thoroughly as their peculiarities merit, it is hoped that the notes and illustrations given may have a certain interest from the fact that they deal with plants which are either wholly new or have been unobserved for twenty years or more since their original description.

MONOBLEPHARIS Cornu.

In a brief preliminary notice which appeared in the Bulletin de la Société Botanique,[1] Cornu first announced the discovery of a most remarkable and important genus of aquatic fungi which, on account of the fact that it was supposed to produce zoospores having a single cilium, was named by him "Monoblepharis." In the following year this writer's well-known "Monographie des Saprolégniées[2] was published, in which he describes and figures two species of the genus, *M. sphaerica* and *M. polymorpha*, referring incidentally to a third, *M. prolifera*, which is neither described nor figured. The last name subsequently remained a *nomen nudum* until the form was rediscovered and sufficiently described and figured by Reinsch, in an important paper published in 1878,[3] under

[1] **28:** 59. 1871.
[2] Annales des Sciences Nat. Bot. V. **15:** 82. 1872.
[3] Pringsheim's Jahrb. f. wiss. Bot. **11:** 293. —.

the name *Saprolegnia siliquaeformis.* In the following year a criticism of Reinsch's paper was published by Cornu in which he asserts that the *Saprolegnia siliquaeformis* of Reinsch is his own *Monoblepharis prolifera.* Since this time there have been no further contributions to our knowledge of the genus with the exception of certain further notes and figures by Cornu in Van Tieghem's Traité de Botanique. In 1892 A. Fischer[4] distinguished *Monoblepharis prolifera* Cornu under a new genus *Gonapodya*, placing the two genera by themselves in a family of Monoblepharidaceæ equal in value to the Saprolegniaceæ under the order Saprolegniinæ, in which he is followed a year later by Schroeter.[5]

Gonapodya being, however, apparently unrelated to Monoblepharis will be considered in a subsequent note and the order may be assumed to include the single genus from which it takes its name, of which but two species (*M. sphaerica* and *M. polymorpha*) have, up to the present time, been observed and described by Cornu alone as above stated.

The family owes its importance chiefly to the fact that among the whole group of Phycomycetes it presents the only instance in which a female cell or oosphere is fertilized through the agency of actively motile antherozoids. The striking resemblances which exist between its reproductive processes and those of algæ like Vaucheria or Œdogonium are too self-evident to need enumeration. To those who, like the writer, are unwilling to believe that the fungi form anything in the nature of a series derived like the series of Algæ from a common origin at its base, it has an especial interest; since it affords one of the strongest arguments in support of the theory which would view the fungi as a heterogeneous group of degenerate forms derived at different points from the different types of the algal series.

The species which have come under the writer's notice are four in number including *M. polymorpha*, and a second form related both to this species and to *M. sphaerica;* but like the former maturing its oospores outside the oogonium. The two remaining species which are considered in the present note, though closely allied to one another, are very distinct from either of the remaining forms, corresponding in the position of their antheridia to *M. polymorpha* while they resemble *M.*

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[4] Rabh. Kryptogamenfl. Abth. I. **4**: 378. 1892.
[5] Engler and Prantl, Natürl. Pflanzenfam. 93: 106. 1893.

sphaerica from the fact that they mature their oospores within the oogonium. Although the development of these forms confirms in most respects the observations of Cornu, a brief account of their life history may not be superfluous.

The hyphæ of all the species of Monoblepharis are almost always recognizable at a glance from their elegant and characteristic vacuolation, the protoplasm forming a network of finely granular strands the meshes of which are often remarkably regular in size and form, while in these strands the coarser granules may be seen moving with considerable rapidity. Thus in the smaller forms the strands commonly cross the filament nearly at right angles, and one seldom sees the more or less longitudinal arrangement of the granules so often characteristic of the Saprolegniaceæ. The fertile hyphæ may arise in considerable numbers from a more or less well developed creeping and branching base which is fixed to the substratum by terminal rhizoidal attachments, and in the two species under consideration, which may be called *M. insignis* and *M. fasciculata* respectively, are rigid in habit, tapering but slightly, rarely branched and without septa except in connection with the reproductive organs. According to Cornu the hyphæ, unlike those of other Phycomycetes, give no test for cellulose; but the writer does not feel as yet fully satisfied with his own observations on this point.

The antheridia in these species are invariably terminal organs, either at the tips of the main axes or of lateral outgrowths from them, while the oogonia are always intercalary. In *M. insignis*, for example, a terminal more or less conical cell is separated by a septum to form the first antheridium (fig. 1*a*). The portion of the hypha just below this septum then enlarges producing a lateral projection (the "neck" of the oogonium), the young oogonium thus formed separating itself by a second septum from the hypha below it. The antheridium thus appears to be borne directly upon the oogonium. In the species just mentioned, after the formation of the first oogonium, a lateral branch begins to form just below it (fig. 3), the tip of which is cut off as before to form a second antheridium, while its base and the upper part of the hypha below it enlarge together to form a new oogonium from which a neck is laterally developed as before. The whole is then separated from the unmodified axis below by an additional septum, so that as a result two oogonia are superposed at the tip of the filament on each of which is inserted an antheridium. The same process may be repeated until as many as eight superposed oogonia terminate the fertile hypha. In *M. insignis*, however, oogonia frequently occur in connection with which no antheridium has been formed. In *M. fasciculata* the process is essentially the same; the fertile axis in this species usually producing several terminal branchlets which become converted in a similar fashion into superposed oogonia, in this instance always associated with antheridia. While the oogonium is developing and before it is fully mature, the contents of the antheridium begin to divide into a variable number of antherozoids (in *M. insignis* often at least thirty-two) and after they are fully formed the tip of the antheridium becomes perforate and the male elements begin to escape slowly, emerging through an at first very small orifice, and dragging behind them a single slender cilium. Several antherozoids usually succeed one another in making their exit, collecting near the tip of the antheridium and going through continuous amoeboid changes of form. After about five minutes the cilia begin to vibrate and the antherozoids swim off with a rapid jerky motion. Meanwhile the remaining antherozoids creep about on the inner wall of the partly emptied antheridium escaping at irregular intervals singly, or several in succession, through the orifice which finally becomes so greatly enlarged that the last antherozoids are able to make their exit without any considerable change of form. Cornu states that both the zoospores and antherozoids make their escape in a quite characteristic fashion, each drawing out its successor from the antheridium by means of its cilium, but this seems certainly not to be the case, the exit being accomplished by means of amoeboid movements, each antherozoid escaping independently of those which have gone before it.

The free swimming antherozoids are nearly spherical or broadly oval in form, with a few refractive granules and a large central nucleus. They move with considerable rapidity, the cilium being directed backwards, and may often be seen to come suddenly to rest on an unfertilized oogonium over which they begin at once to creep with an amoeboid motion.

When the antheridium has become partially emptied, the escaping antherozoids do not all swim off in the surrounding water; but some of them at least begin to creep with amoeboid movements over the surface of the antheridium and thence over the oogonium, the single cilium projecting outward somewhat obliquely. In this way they may take journeys of considerable length, creeping around the oogonium, down to the hypha which bears it, and then back again; sometimes disengaging themselves and swimming away as already described.

In the meantime, usually after about one-third of the antherozoids have made their escape, the oogonium, having reached maturity, opens. Before this occurs the main body of the organ is filled by a mass of very coarsely granular protoplasm, its projecting neck being filled with a more finely granular contents which also extends around the coarser mass. The dehiscence of the oogonium is effected by pressure from within, a rupture occurring at the tip of the "neck," through which a large amount of the finely granular contents is discharged with considerable force (fig. 4). This discharge is occasionally so violent that a small amount of the coarsely granular content is also discharged, which, instead of becoming at once dissipated in the surrounding water like the finely granular protoplasm, coheres in aspherical mass and exercises an attractive influence on passing antherozoids (fig. 5). After the dehiscence of the oogonium its remaining contents contract into an oosphere of definite contour (figs. 4, 5) which is then ready for fertilization. The antherozoids soon creep up over the neck and through the opening at its tip, making their way into the oogonium and moving along its inner wall down to the oosphere. As many as eight antherozoids have been seen in a single oogonium; but only one appears to fuse with the oosphere in the fashion described by Cornu, the cilium projecting upwards and the body slowly sinking into the substance of the oosphere (fig. 5). In some instances an antherozoid which has just escaped from the antheridium may be seen to stretch across to the adjacent tip of the oogonium into which it makes its entrance without the usual preliminary perambulations. Fertilization having been thus accomplished, the oospore surrounds itself with a smooth thick wall, and, in both the species under consideration, remains within the oogonium at maturity. Although the oospores have been kept in water for several weeks, no signs of germination have been as yet observed; but it seems more than probable that this takes place by means of zoospores of the usual type.

The zoospores, which are very rarely produced in *M. insignis* but are found more commonly in *M. fasciculata*, are more than twice as large as the antherozoids. According to Cornu the zoospores resemble the antherozoids in all respects except in size; but, although the writer has not thoroughly satisfied himself on this point in his examination of fresh material, stained preparations of the zoosporangia of *M. fasciculata* show distinctly two cilia on zoospores which had not as yet escaped when the preparation was made (fig. 12). In both of the present species, as is also frequently the case in *M. polymorpha*, the zoosporangia resemble the oogonia in all respects (figs. 7, 11, 12) and are formed in exactly the same way, usually in connection with an antheridium. The long clavate sporangia, however, which are also characteristic of *M. polymorpha*, have not been observed in either of the new species. After the escape of the zoospores a large oil globule always remains within the sporangium. Further details concerning *M. polymorpha* and the additional species above referred to are withheld for the present. The two remaining forms may be characterized as follows:

Monoblepharis insignis, nov. sp.—Hyphæ straight, rigid, hyaline or very pale reddish brown, nearly cylindrical, rarely branched, 1.5–2.5^{mm} in length by 8–15μ in diameter. Antheridia broad, subconical to subcylindrical, straight or slightly divergent, the rounded tip often bent slightly inwards, nearly symmetrical or often with the base irregularly protruded on its inner side. Antherozoids numerous (about 24–32), 1-ciliate. Oospores maturing within the oogonium, smooth, pale amber-brown, spherical to long oblong or irregular in outline, 30–45×22–33μ. Oogonia single or several superposed at the tips of the hyphæ, irregular in form. Zoosporangia rare, similar to the oogonia; zoospores 2-ciliate (?), about 10–12μ in diameter.

On submerged sticks in pools and ditches, Weston and Medford, Mass., and Kittery Point, Maine.

This species appears not to be uncommon and is conspicuous from its large size and striking appearance. It was found growing with Œdogonium and other forms in the situations mentioned, and on account of its greater dimensions is better adapted than either of the much smaller remaining species to demonstrate the characteristic processes of reproduction. It varies considerably in the size of its filaments, as well as in the size and form of its oogonia and oospores, the latter often following the contour of irregular oogonia in which they may have been formed.

Monoblepharis fasciculata, nov. sp.—Hyphæ straight, rigid, cylindrical, simple or rarely branched except at the tips, 1–2^{mm} long by 6μ in diameter. Antheridia narrow, tapering slightly, straight, not divergent. Antherozoids about sixteen in an antheridium, 3μ in diameter. Oogonia evenly oval oblong or elliptical, the neck small and prominent, usually shorter than the antheridium which is always present, single and terminal or borne superposed on short crowded branches from the tips of the fertile hyphæ. Oospores more or less regularly oval oblong or elliptical, smooth, pale amber-brown, maturing within the oogonium, $22 \times 18\mu$. Zoosporangia lik e the oogonia, bearing antheridia: the zoospores 2-ciliate, about 5–6μ in diameter.

On submerged sticks with the last. Weston and Medford, Mass.

This species, which seems to be much more rare than the preceding, has been found but twice in the localities mentioned. It seems to be abundantly distinguished from the last by its constantly smaller size and the greater regularity and different form of its sexual organs and spores, as well as by its fasciculate habit.

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Explanation of Plate XXIX.

Monoblepharis insignis Thaxter.

Fig. 1. Group of fertile hyphæ bearing oogonia terminally. *a*, hypha from the tip of which an antheridium has been cut off.

Fig. 2. Oogonium and antheridium neither of which have yet opened. A new oogonium beginning to form below the first.

Fig. 3. An oogonium still closed, over which two antherozoids from the partly emptied antheridium are creeping.

Fig. 4. The same ten minutes later; the oogonium just opened and discharging the finely granular protoplasm at its tip; the coarsely granular part having contracted to form the oosphere: four antherozoids still remain within the antheridium, one of which is just escaping.

Fig. 5. Oogonium from which a portion of the coarsely granular contents has been discharged in two masses on the larger of which two antherozoids are creeping: within the oogonium are two antherozoids one of which has almost fused with the oosphere.

Fig. 6. An empty antheridium and an oogonium which has been entered by four antherozoids.

Fig. 7. An oogonium in which fertilization has taken place; below it a zoosporangium from which the zoospores are just ready to escape.

Monoblepharis fasciculata Thaxter.

Fig. 8. Group of fertile hyphæ with oogonia at their tips.

Fig. 9. Unopened oogonium and antheridium below which a branch is forming.

Fig. 10. Oogonium with mature oospore.

Fig. 11. Oogonium and zoosporangium from which a few zoospores have escaped: the sporangium terminated by an antheridium.

Fig. 12. A similar specimen in which three zoospores still remain in the oogonium together with a large residual oil mass.

*** Note —Figures 1 and 8 are drawn with Zeiss obj. A, oc. 4. The remainder with obj. D, oc. 4.